MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, SESSION 2021/2022

EEL4126 – POWER SYSTEM OPERATION AND CONTROL

(LE)

10 AUGUST 2022
9:00 am – 11:00 am
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question Paper consists of 4 pages including the cover page with **FOUR** Questions only.

2. Answer **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided.

Question 1

(a) Economic Operation can be subdivided into two parts as below:-

(i) Problems of the Economic Dispatch [2 Marks]

(ii) Problems of Optimal Power Flow [2 Marks]

Defined for both problems and how they differ from each other.

(b) The total load of a power system is supplied by four generators. The cost characteristics of these generators are given as:

$$C_1 = 150 + 3.0\,P_1 + 0.010\,P_1^2 \text{ RM/Hr}$$
$$C_2 = 80 + 4.0\,P_2 + 0.020\,P_2^2 \text{ RM/Hr}$$
$$C_3 = 100 + 3.6\,P_3 + 0.0125\,P_3^2 \text{ RM/Hr}$$
$$C_4 = 70 + 4.2\,P_4 + 0.0125\,P_4^2 \text{ RM/Hr}$$

The ratings of the generators for P_1 to P_4 are 225 MW, 200 MW, 175 MW and 150 MW; respectively. Given the total load on the system is equal to 520MW.

(i) Calculate the incremental fuel cost. [6 Marks]

(ii) Based on the Part (i), design for the optimal economic dispatch condition. [5 Marks]

(iii) Calculate the cost of operation at optimal economic dispatch. [5 Marks]

(c) Unit commitment problem in power system can be very challenging. If you own a power plant that consists of three units generator with the following cost characteristics:

$$C_1 = 0.0040\,P_1^2 + 7.20P_1 + 350 \text{ RM/Hr}$$
$$C_2 = 0.0025\,P_2^2 + 7.30P_2 + 500 \text{ RM/Hr}$$
$$C_3 = 0.0030\,P_3^2 + 6.74P_3 + 600 \text{ RM/Hr}$$

With P_1, P_2, and P_3 are generating power in MW; the maximum and minimum loads allowable on each unit are 500 MW and 50 MW, respectively, calculate the full-load average production cost for each generating units and hence obtain the priority list based on the calculated answers. [5 Marks]

Continued...

Question 2

(a) Name two methods that could be used for AC power flow program for contingency analysis. [2 Marks]

(b)

(i) Defined the term of 'security constrained power flow'. [2 Marks]

(ii) List 3 major components of 'security assessment'. [3 Marks]

(c) 3-bus power system shown in Figure Q2, where all are in per unit values. Assume Bus 3 is the reference bus.

(i) Find the base power flows on the transmission lines. [15 Marks]

(ii) Calculate the generation shift factors for line 1-2. [3 Marks]

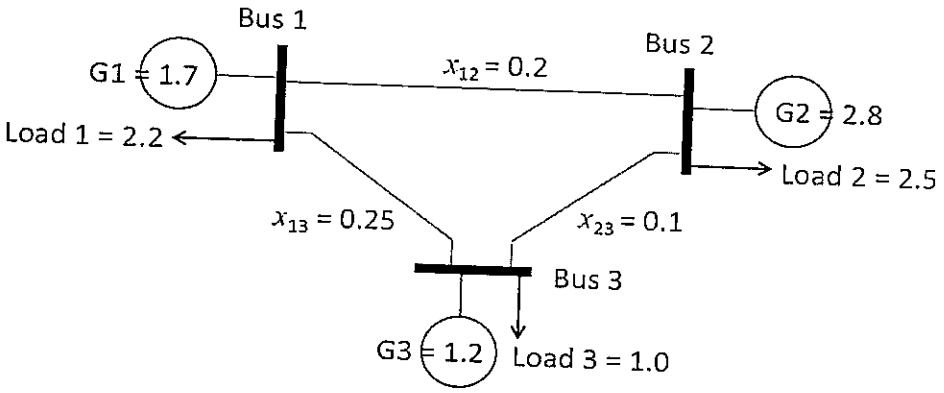

Figure Q2

Question 3

(a) Draw the block diagram of an interconnected two-area system having tie-line bias supplementary control. [10 Marks]

(b) Figure Q3(b) shows the block diagram of governor, prime-mover and rotating mass.

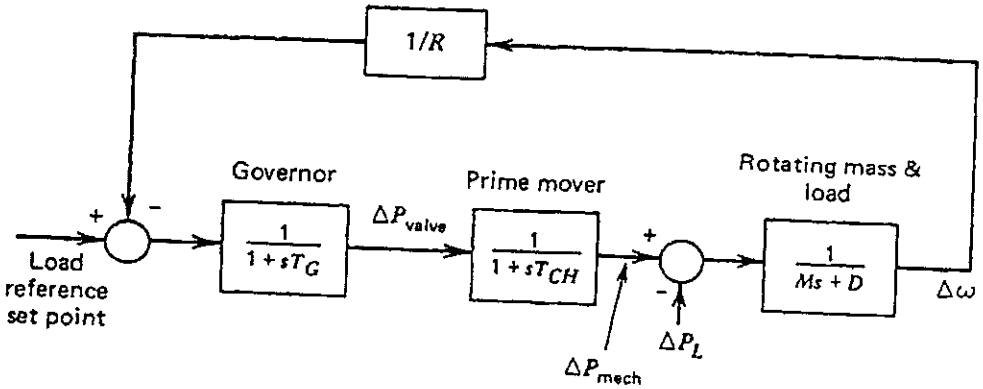

Figure Q3(b)

Continued...

(i) Show that the transfer function, $C(s)$, relating the load change, ΔP_L to the frequency change, $\Delta\omega$, is given by

$$C(s)=\frac{\Delta\omega}{\Delta P_L}(s)=\left[\frac{-\left(\frac{1}{Ms+D}\right)}{1+\frac{1}{R}\left(\frac{1}{1+sT_G}\right)\left(\frac{1}{1+sT_{ch}}\right)\left(\frac{1}{Ms+D}\right)}\right]$$

[8 Marks]

(ii) Determine the per unit steady-state change in frequency, $\Delta\omega$ for a step load change of ΔP_L. [4 Marks]

(iii) What would be the change in speed if D is zero? [1 Mark]

(iv) What is the frequency change if several generators with each having its own governor and prime mover were connected to the system? [2 Marks]

[Hint: For parts (ii) – (iv), leave the answer in general form.]

Question 4

(a) Define the following terminologies of excitation system: excitation ceiling voltage, excitation system ceiling currents, excitation ceiling voltage time response, excitation system voltage response time, high initial-response excitation system. [10 Marks]

(b) Sketch and explain on the block diagram of potential-source controlled-rectifier excitation system. [15 Marks]

End of Paper.